FINAL REPORT
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Economical Supply of Mesquite Biomass for Energy Uses
(SECO Contract CM-406)

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With Industry Partners:
Bio-Star Inc., Vernon, Texas
Pearson BioEnergy, Inc., Aberdeen, Miss
W.W. Welding, Altus, OK
Brush Unlimited, Inc., Altus, OK

Introduction and History

The SECO Grant CM-406 was awarded to Dr. Ansley at the Texas Agricultural Experiment Station (TAES) in July 2003. The funding was transferred to Dr. Ansley's project in February 2004 and experiments related to the objectives began shortly thereafter. Much of the success of the project hinged on two factors: first to develop a mechanical method to harvest woody shrubs on rangeland, and second, to run test trials with one of the industry collaborators to determine if mesquite wood could be converted to ethanol. These two factors were very dependent on the collaboration and cooperation of industry partners. We were reasonably successful in these collaborations, but significant problems were encountered that delayed the original schedule of milestones considerably. We asked and received three extensions of the funding cycle to accommodate these delays.

We were also forced to ask one of the original collaborators, Justice, Inc., to withdraw from the project as production demands in their own business prevented them from freeing enough time to work on this project. Fortunately, we were able to secure two other industry collaborators who helped complete Objectives 1 and 2a of the project. A significant infusion of additional funding from TAES was used to complete these Objectives. We are greatly indebted to the cooperation of Brush Unlimited, Altus, Oklahoma (Richard Frailey, owner) and W.W. Welding, also from Altus (Larry Willis, owner), without whom, Objective 1 would not have been completed. They have provided an excellent example of a successful collaboration between university researchers and the private sector. A summary of the contributions of all collaborators is shown in Appendix A.

The capstone event of the project, a field day on October 5, 2006 (as part of Objective 4), was a huge success and demonstrated the potential of this cellulosic biofuel source to the general public as well as to several prominent politicians that attended. Subsequent web site and news articles have featured various aspects of the study, and this has greatly increased the awareness and potential of alternate fuel sources.

We have yet to publish a peer-reviewed article using data from this project, mainly because we were only able to begin the first test trials of the harvester in late 2005. As a result, some of the news articles and web site sources have given misinformation about the commercial availability of the harvester and/or the cellulosic conversion technology. However, these articles are the exception, and most articles have been positive as well as realistic. The most interesting thing about the press coverage is that this has hit a positive note with both the ranching/farming clientele as well as the urban public who are concerned with developing alternative fuel sources. It appears we are on the right track with this line of study, but we still need to fill many information gaps. Funding from SECO provided a start to this important work.

We present in this final report, a listing of the original objectives, and then a narrative, photographs and data collected that is related to each objective. The data presented are not comprehensive, but provide an indication of the kinds of data we collected. We anticipate publishing at least one peer-reviewed manuscript related to objective 2a that will feature the performance characteristics of the mesquite harvester. We also plan two more peer-reviewed publications related to various aspects of objective 2b. In this objective, we harvested individual mesquite plants of various known regrowth ages following a top-kill disturbance and partitioned the above ground tissue into different components. To our knowledge, these kinds of data regarding biomass of mesquite regrowth have not been published so we anticipate readily publishing this.

We provide a general economic overview related to Objective 3. However, much of this information has depended on data provided by one of our industry collaborators, Pearson BioEnergy. Much of their operation is proprietary and details have not been made available to Dr. Ansley. Therefore, data related to Objective 3 below should be considered tentative at best and we currently do not plan to publish results related to this objective until we can independently verify Pearson's numbers.

The primary focus of Objective 4 was education, outreach and information transfer to clientele. We currently have no plans to publish any portion of this in a research journal, but we do plan to publish portions of this as non-technical articles in trade journals or similar outlets. However, the hundreds of web site, newspaper and trade journal articles that have been published by outside reporters have helped magnify the impact of this objective beyond anything we imagined when we first began the project. We believe the project has clearly improved public awareness of the need to develop alternative energy sources and, in particular, a biofuels industry in Texas.

Original Objectives from the Proposal

(1) Refine existing technology for (a) harvesting, (b) baling and (c) lifting and loading mesquite biomass,

(2) Quantify costs associated with harvesting and baling mesquite biomass by (a) determining harvest costs in stands differing in density, size and tonnage per acre, and (b) determining the length of time needed before re-harvest is economically possible by quantifying biomass of regrowth mesquite,

(3) Determine the potential of mesquite wood for conversion to ethanol using Pearson Technology,

(4) Enhance cost-share applications through outreach and information transfer to consumers, farmers and industry.

Summary for Each Objective

Objective 1

As described in earlier reports, this objective was modified to focus only on the construction of a harvesting machine that would gather pre-cut, mulched wood. We realized after the project began that it was not feasible to include, within the same machine, the capacity to simultaneously cut down the mesquite trees and pick up the wood. Thus, we developed an alternate system that encompasses a two-phase process that first uses existing machines to cut the trees down (Figure 1), leaving a very rough wood mulch on the ground (Figure 2). We would then use another machine, still to be designed and constructed, to pass over the same ground and gather the mulch.

Construction on the mulch-collecting harvesting machine was first attempted by Justice Inc., in Sterling Colorado. However, after about a 17 months of little activity (January 2004-May2005), it was determined that Justice was not going to be able to complete the job and they withdrew from the project. Dr. Ansley had been working on another option for harvesting with two companies in Oklahoma and remaining resources from the SECO grant were combined with another grant that had been used for construction of a second harvester.

Figure 1 – View of a Barko 775C wood mulcher that is commercially available.

Figure 2 – View of mesquite wood that is left on the ground after the Barko 775C fells the trees.

The new harvester was fabricated by W.W. Welding Co. of Altus, Oklahoma. It was co-designed by Richard Frailey, Brush Unlimited, Inc., Altus, Larry and John Willis, W.W. Welding, Dr. Jim Ansley, TAES, Vernon and Montey Sneed, Vernon. Mr. Frailey is the primary designer and will market the commercial construction and sales of these machines.

We realized after the project started that it was not possible within the economic constraints of each grant to construct a baler for the harvesting machine. Therefore, we instead designed and constructed a hydraulically-lifted mulch collection basket that was removed from an old cotton harvester at no charge to the project and mounted to the harvesting machine (Figure 3).

Primary construction of the mesquite mulch harvester began in May 2004 and was completed in November 2005, but modifications continued to be made throughout 2006. Dimensions of the machine are 21 ft length x 9 ft width x 12 ft height. Total weight is estimated at 7-8 tons (Figure 4). The machine is not self-powered and must be pulled by a tractor with a PTO connection and hydraulic connections to lift the collection basket and the cutting head. Mr. Frailey of Brush Unlimited has kindly donated the use of his tractor that is specially configured to ride over down thorny brush to pull and power the harvester at no charge to the project.

Total cost for the construction of the mesquite harvester, as of December 31, 2006, was $43,415. The Texas Agricultural Experiment Station, Vernon, contributed $31,103, and the SECO grant contributed $12,312, or 28%, toward this total. Industry collaborators, W.W. Welding, Richard Frailey of Brush Unlimited, and Montey Sneed, contributed an additional $50,000, in design and labor time that they did not charge for. Ansley and his support staff contributed additional time so the total real cost to build the machine was over $100,000 (see details in Appendix A).

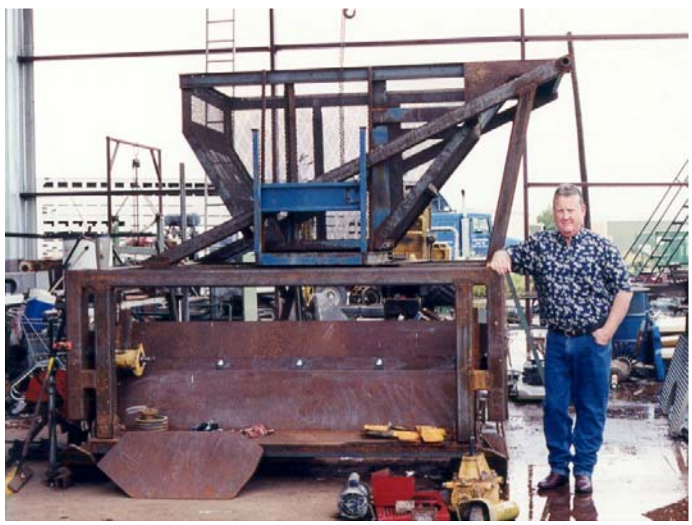

Figure 3 – Front view of harvester during construction showing the cotton harvester collection basket that was mounted to the top of the machine. Monty Sneed is in the photo.

One of the most significant features of the machine is the Seppi 225 meddi-force “flail-type” cutting rotor. This Italian-built rotor is very tough and is built to handle dense wood material. This rotor would normally sell for $15,000, but we were able to obtain it for $5,000 from Carlson, Co. in Minnesota through negotiations by Mr. Frailey, who is a long-time customer of Carlson. Thus, the project saved $10,000 in construction costs. In addition, as mentioned earlier, the harvester basket was pulled off an old cotton harvester at no extra charge. If these cost saving measures had not been done, the actual total cost would have been much greater.

Figure 4 - View of the mesquite mulch harvester during the first field operation trial (photo November 2005).

Objective 2a

The first harvest trial on mesquite using the new machine was conducted on March 16, 2006 on a private ranch north of Altus, Oklahoma. The ranch had a dense stand of multi-stemmed mesquite. At the time of the harvest there was no foliage on the mesquite. Pre-harvest data were colleted along six 30 m long transects and indicated that mesquite canopy cover, tree height, stems per tree and density were 64% (se 7.3), 3.3 m (se 0.2), 4.5 (se 1.0), and 833 trees per hectare (se 121), respectively. Density could also be expressed as 337 trees per acre. This is higher than an average density of 200 trees per acre that we have made in our economic projections and suggests the standing mass of wood in this stand was over 10 tons per acre.

The standing mesquite trees were mulched on March 14, 2006 using a commercial HydroAxe machine with a Seppi 200 meddi-force flail head, owned by Mr. Frailey (at no cost to the project). A 100 m x 60 m (0.6 ha or 1.48 acres) area was cut down. Time to cut was 1.5 hours, or about 1 acre per hour. The entire process used about 4 gallons of fuel.

Two days later the harvester machine was tested over the downed mesquite wood mulch to determine rate of progress, fuel use and degree of pickup (Figure 5). This machine has a Seppi 225 meddi-force flail head and was pulled and powered by a Case International tractor with a 1000 rpm PTO. The gearbox on the harvester machine increased the Seppi head rpm to 2000. The tractor and operator was provided by Mr. Frailey at no extra charge.

The site had been badly overgrazed due to recent drought and the herbaceous layer was almost non-existent. Thus, there was a great deal of bare ground and the harvest trial was extremely dusty. We estimated that about 60-70% of the woody mulch material was picked up. The lack of a grass surface, we believe, reduced harvest efficiency because there was no resistance of the soil to the vacuum effect of the harvester Seppi head.

Figure 5 – View of the mesquite mulch harvester with tire of Mr. Frailey's International tractor on the left pulling the harvester and supplying power through a PTO connection (photo March 16, 2006). Standing trees that were not mulched are in the background. Woody debris of felled trees is shown in the foreground.

The machine made two complete circles of the unit [total distance = (100 m x 4) + (60 m x 4) = 640 m, or 2100 feet]. However, the trial ended at that point because the drive belt to the gear box broke. The total area harvested before breakdown was a 2100 ft x 8 ft swath width, or 16,800 ft^2. This represented about 25% of the total area of 1.48 acres (64,469 ft^2).

We estimated the rate of operation over this type of wood mulch was 1 second per meter. To harvest the entire 60 x 100 m area would require 25 passes along the long axis, assuming an 8 ft (or 2.4 m) swath width (i.e., 60/2.4 = 25), with each pass 100 m long. Thus the total time taken could be estimated at 2500 m x 1 sec/m, or 2500 seconds, or 41.7 minutes. Total harvest time was thus projected at 41.7 minutes/1.48 acres, or 28 minutes per acre. Conservatively, we rounded this to 30 minutes per acre.

The right hand portion of Figure 6 shows what the original stand looked like before the HydroAxe machine mulched the wood. The far left of Figure 6 shows what the mulched wood looked like while lying on the ground. In the middle of Figure 6 is a swath cut by the mesquite harvester showing that most of the mulch debris was lifted. As can be seen, some of the smaller material remained on the ground.

Estimated fuel use to fell the area was 6.1 gallons per acre. Fuel use to harvest using the harvester was 11.5 gallons per acre. Thus, total fuel use was 17.5 gallons of diesel per acre. It took approximately 3 hours per acre to complete the harvest but we viewed this as an area that could really be improved upon because of our inexperience operating the machine.

Figure 6 – Mesquite stand near Altus that has had the left portion mulched. The middle lane is where the harvester had made one pass (photo March 16, 2006).

With 25% of the area covered, the mulch collection basket was nearly filled (Figure 7). The capacity of the mulch collection basket is 6ft high x 6 ft long x 9 ft wide, or 324 cubic feet. We estimate we accumulated 250 cubic feet of material. We were unable to operate the hydraulic lifting mechanism of the basket after the first load was filled, however, due to a mechanical failure that we were not able to fix in the field. Thus, the trial was shortened to take the machine to the shop for repairs. However, the first trial on mesquite wood was considered a success.

Figure 7 – The mesquite harvester showing the collection basket nearly full after two passes in the mulched area (photo March 16, 2006).

The remaining wood from the March 2006 trial north of Altus was harvested in June 2006. Complete harvest was delayed as the harvester needed to be repaired between March and June. The wood from 1.5 acres was deposited near Mr. Frailey's headquarters in Altus, OK. A photo of the total pile (wood + soil) is shown in Figure 8. A considerable amount of soil was picked up in the process because the site had been badly eroded due to overgrazing. Thus, to get an adequate estimate of the actual wood that was picked up, about 2/3 of the pile was screened to remove the soil from the wood in July (Figure 9). Total wood weight was estimated to be 2.31 tons. Total soil weight was estimated at 1.98 tons. The largest pieces of wood found were 5 inches in diameter and about 3 to 4 feet long, but most pieces were much smaller.

Total fuel use was 17.5 gallons per acre. If fuel was estimated at $2.50 per gallon, then fuel cost was $43.75 per acre. Cost per ton to harvest was thus $43.75/2.31 tons = $18.94. We feel that the efficiency of harvest was compromised with the amount of bare ground and anticipate greater efficiency and lower cost per ton in future test trial that we will conduct this fall.

Shortly after the October 5, 2006 field day, several more field trials were conducted on different size and density mesquite. These trials were conducted near Vernon and consisted of either one-acre or one half-acre sized patches that were first felled by the Barko 775C and then harvested by the TAES harvester. The HydroAxe was used to pull and power the harvester. In addition, the power system was converted to a hydraulic drive instead of a PTO.

Figure 8 – The mesquite wood pile from 1.5 acres of mesquite that was harvested using the harvester in March and June 2006. The yellow tape indicates 1 meter in length. Total volume of the pile, which contained an unknown amount of soil, was 8.8 m^3 (311.1 ft^3).

Figure 9 – The system to separate mesquite wood mulch from soil using screen boxes in center of the photo. The yellow tape on right is 1 meter. The clean wood is in the trailer and the remaining unscreened pile is on the right. Smaller wood chips that passed through the 1 x 2 inch screen are on the left.

Time to fell or harvest and fuel use of each machine was measured during each trial. Tree size and density prior to felling was also measured. Time to fell the trees ranged from 12 to 36 minutes per acre. Time to harvest ranged from 118 to 174 minutes per acre. Fuel use ranged from 15 to 24 gallons of diesel per acre. Because we do not have the wood yield data yet, it is impossible to determine the cost per ton. However, if we did in fact pick up 5 tons per acre, then the cost per ton, assuming 25 gallons per acre and $2.50 per gallon, would be near $12.50 per ton. This is based strictly on fuel use and does not factor in labor, machine maintenance or other factors. The trials in lighter density live mesquite and standing dead (previously sprayed) mesquite required much less time and fuel per acre. Data are currently being assimilated into a manuscript.

The wood that was harvested in each trial (except for the first trial reported earlier) remains in small piles at each trial site and will be processed in January-March 2007 to determine wood yield per acre and cost to harvest per ton. Figure 10 shows a wood pile from one of the trials conducted in a section of dense mesquite near Vernon.

Figure 10 – Wood pile of a harvested area near Vernon. Mr. Richard Frailey is in the image.

Objective 2b

Individual mesquite trees of different known regrowth ages were harvested in 2004, 2005 and 2006. Regrowth ages ranged from 2 to 12 years. These trees were compared to undisturbed trees that were of similar height of each age of regrowth trees. We measured outside dimensions and stem number of each plant prior to cutting. Then entire above ground contents of each tree was harvested using a chain saw and placed into a 4 x 8 ft drying box that had a screen on top (Figure 11).

Each tree was later divided manually into wood and leaf components (Figure 12). Trees were separated into leaves, current year twigs (<1 cm diameter), old twigs (<1 cm diameter), small wood (1 to 3 cm diameter; about 0.25 to 1.25 inch diameter) and large wood (>3 cm diameter). Components were oven dried and weighed. Drying in the wood boxes greatly facilitated removing the leaves from the stems. The screen on the box allowed the tree material to dessicate so that the leaves were easily removed. These boxes were not used for the 2004 trees but were used for 2005 and 2006 and it took half the time to process these trees as it did in 2004.

As an example, the total oven dry weight of a 12 year old tree shown in Figure 13 was about 130 pounds. At a density of 250 trees per acre, regrowth trees of this age and size would yield 16 tons per acre. In contrast, Figure 14 depicts a 4 year old regrowth mesquite that was harvested and had a total oven dry weight of 10 pounds. At similar tree densities of 250 per acre, this would only yield 1.25 ton per acre.

Figure 11 – Four foot by 8 foot drying boxes that contain individual harvested mesquite trees.

Figure 12 – Two summer workers, one supported by SECO funds, are processing one of the 12 year old regrowth trees in our shop. The other worker was supported by Texas Agricultural Experiment Station Funds. The wood is divided into leaves and different sized stems.

Figure 13 – A 12 year old multistemmed regrowth mesquite that was harvested shortly after this photo was taken. The tree is about 4 meters tall (pole is 3 meters).

Figure 14 – A 4 year old multistemmed regrowth mesquite. The tree is about 1.5 meters tall (the pole is 3 meters) and had about 40 basal stems.

Regrowth consistently had greater mass per tree than trees of similar height for each regrowth age. For example, total tree mass of 4-year-old regrowth mesquite was 248 % greater than that of trees of undisturbed trees that were of a similar height (10 vs. 3 lbs/tree). Total tree mass of 10-year-old regrowth mesquite was more than twice (116 %) that of trees of similar height that had not been disturbed (82 vs. 38 lbs/tree). Total tree mass of 12-year-old regrowth mesquite was 43% greater than that of trees of similar height that had not been disturbed (130 vs. 91 lbs/tree).

The primary reason for the greater total tree mass in regrowth trees is because regrowth trees had more basal stems than undisturbed trees. However, the number of basal stems in regrowth mesquite declined over time, and this explains why the differences in total mass between regrowth and undisturbed trees, while still much higher in regrowth trees, also declined with increasing age of the regrowth.

Leaf mass was consistently greater in regrowth trees than in undisturbed trees, suggesting that regrowth trees are more competitive with grasses due to greater potential for leaf transpirations. Current year twig mass was only greater in regrowth than undisturbed trees when regrowth was 4 years old. However, old twig mass was greater in all ages of regrowth trees than undisturbed trees. Large stem (> 3 cm diameter) mass did not appear until 7 year old regrowth, but increased to over 50 lbs per tree in 12 year regrowth. This value was similar to the large stem mass of undisturbed trees that were the same height as 12 year old regrowth. Thus, large stems mass, which could be considered as the most important component of the mesquite tree with respect to biofuel potential, was similar between regrowth and undisturbed trees at the 12 year regrowth age.

There are several reasons for this, but the most likely is that undisturbed trees gain height very slowly after they are about 20 years of age. Most of the mass of these trees, after seedling and juvenile development, is in radial growth of the basal support stems. Thus, a difference in 1 foot of height of these trees could actually mean a difference of 20 years in age and the concomitant large difference in basal stem diameter and wood weight. For example, undisturbed trees that were 11.6 and 11.5 feet tall (matching trees for the 10 and 11 year old regrowth, Table 2) had a large wood mass of 12.9 and 18.8 lbs, respectively. In contrast, the undisturbed trees that averaged 13.7 ft tall that were the match for the 12 year old regrowth trees, had a large wood mass of 58.4 lbs. Thus a difference in 2 feet in height resulted in a tripling of large wood mass.

Leaf and twig mass, as a percentage of total mass of regrowth trees, declined over time, from nearly 40% in 2 year old regrowth, to 10% in 11 year old regrowth (Figure 15). Small stem mass showed a brief spike in 4 year old regrowth before settling to about 40% of the total mass. As stated earlier, large wood (stems >3 cm diameter) mass did not appear until 7 year old regrowth. Large wood mass increased from 15 to 40 % of the total mass as regrowth age increased from 7 to 11 years, respectively. The proportions of masses of the various tree components of 11 year old regrowth were similar to that of undisturbed trees of similar height.

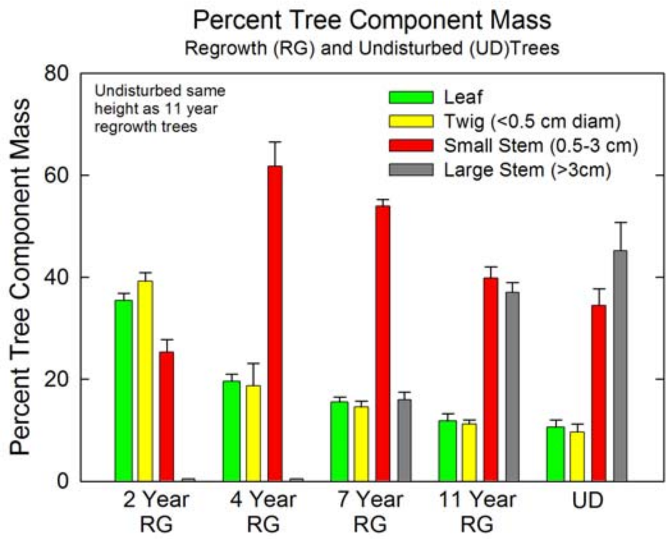

Figure 15 - Percent of the total tree mass of structural components on mesquite of different ages of regrowth (2 to 11 years) and of undisturbed mesquite (UD) that were growing on the same site as the regrowth plants and were of the same height as the 11 year old regrowth trees.

The regrowth age to total tree mass relationship was exponential in that total mass increased at a faster rate with increasing regrwoth age (Figure 16). This trend no doubt will level off at some point but showed no signs of that by the 12th year of regrowth age. At 10-12 years regrowth age, the trees had accumulated about 90-120 lbs of oven dry mass per tree and were about 12-13 ft tall. The undisturbed trees also showed an exponential relationship between height and mass, for reasons explained earlier, although it should be noted that the age of undisturbed trees has not been determined at this time. We preserved stem cross sections and will age these trees by counting the growth rings in the future. We suspect most of these trees are 25-40 years old.

A comparison of the heights of regrowth and paired undisturbed trees is shown in Figure 17. Based on the current results, we project that, if mesquite regrowth was 10-12 years old, that a reasonable value of total oven dry mass appears to be about 100 lbs per tree (Figure 16). Thus, for an average density stand of 250 mesquite plants per acre, the above ground standing crop would be 100 lbs/tree x 250 trees/acre = 25,000 lbs, or 12.5 tons per acre. If a harvesting system was 80% efficient, then this would result in about 10 tons per acre harvested.

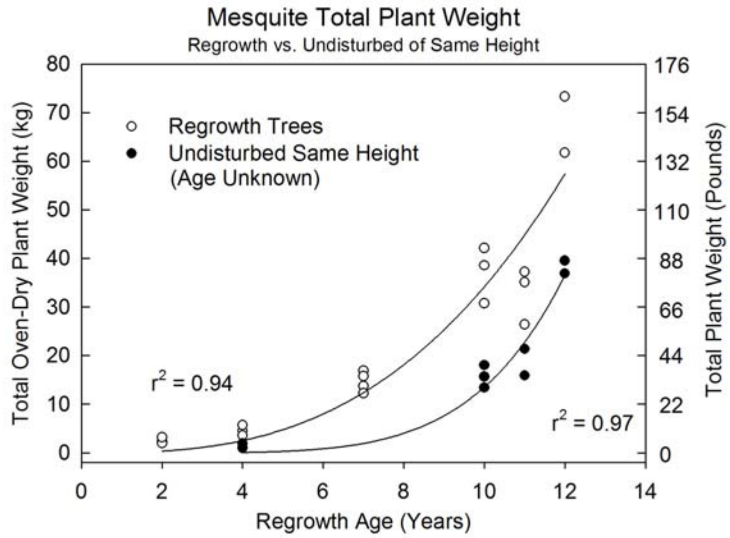

Figure 16 - Total oven dry mass (wood + leaves) of different aged regrowth mesquite compared to undisturbed trees that were the same height of each regrowth age and were growing on the same site. Mass from undisturbed trees do not relate directly to the values on the x-axis. These trees are aligned with their regrowth counterparts based on tree height only.

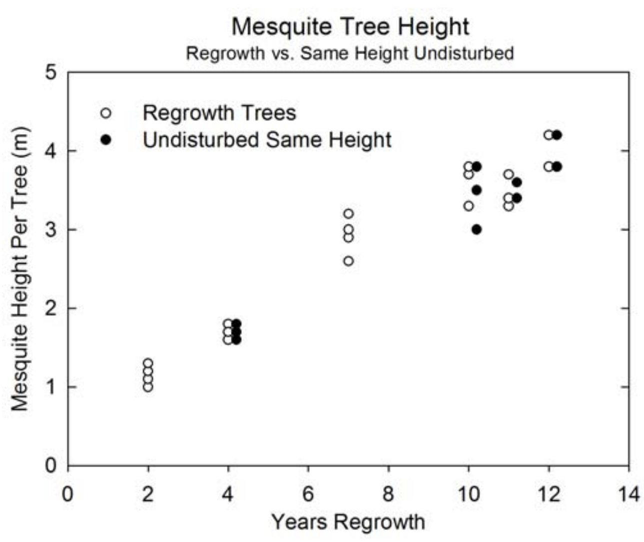

Figure 17 - Height of different aged regrowth mesquite compared to undisturbed trees that were selected to be of similar height to the regrowth trees.

Objective 3

In April 2004, Mr. Sneed and Dr. Ansley harvested about 2 tons of mesquite wood from Vernon and transported it via a U-Haul truck to Pearson BioEnergy in Aberdeen, Mississippi to conduct a series of test runs to determine efficiency and costs of converting mesquite wood to ethanol using the Pearson anaerobic gasification test facility. After running the tests, Pearson claimed that one dry ton of mesquite wood yielded 214 gallons ethanol. We at the Texas Agricultural Experiment Station are uncertain as to the accuracy of the value. The yield value seems high in light of current corn-to-ethanol technologies that yield only 100 gallons per ton. The theoretical maximum ethanol yield of one ton of wood, based on the amount of carbon in wood, is about 300 gallons. However, even this value is not attainable unless more hydrogen is introduced into the system because the hydrogen to carbon ratio is higher in ethanol than it is in wood.

Other researchers suggest that there may be a much higher yield from cellulosic biomass sources, as well as a better overall carbon balance, than is currently attained with corn (Farrell et al. 2005, Tilman et al. 2006). However, this has yet to be commercially demonstrated or implemented. Thus, the values from Pearson must be viewed in this light. We have no way of verifying the ethanol yield estimates provided by Pearson.

We believe that for a mesquite to ethanol industry to be successful, smaller capacity ethanol refineries located near the wood source are absolutely essential. Because mesquite and other rangeland shrubs occur on remote rangeland settings, transportation costs of hauling feedstock from source to refinery must be minimized. A serviceable size of refinery that is compatible to available standing crop is about 5 million gallons per year. This is much lower than current corn ethanol refineries that have a 50 to 100 million gallon capacity. Thus, we are envisioning a completely different approach toward the refinery limitations, but this may be possible with a cellulosic gasification technology such as the Pearson process.

Table 1 summarizes an expected employment scenario for a 5 million gallon per year refinery, based on an initial template provided by Pearson, but expanded by Dr. Ansley at TAES. In this scenario, each refinery would employ 29 people. The refinery itself would operate with 3 shifts and process about 100 tons of feedstock per day and operate about 330 days per year. There would be 7 individuals per shift at the refinery.

The scenario assumes that the refinery would supply its own crew and machinery to harvest the wood and provide the feedstock. This would, of course, depend on long-term contracts established between the land owners and the ethanol company to insure a steady supply of wood feedstock. The field harvesting crew would work as a single shift of 8 people, and harvest about 10 acres per day at 10 tons per acre. We estimate that this would require 2 Barko-like cutting machines and 2 of the A&M harvesters. The field crew would consist of 4 operators and 4 ground level assistants to scout for metal debris that may damage the rotor and also make sure the rotor is elevated enough during the harvesting process so as to not dig into the soil and/or damage grass tufts.

Table 1. Projected scenario of the types of jobs and 'total package' annual compensation associated with each 5 million gallon per year mesquite to ethanol refinery.

EMPLOYEE TYPE AND NUMBER	PER PERSON	TOTAL
At Refinery		
Primary Supervisor	$140,000	$ 140,000
2 Shift Supervisors	$100,000	$ 200,000
12 Refinery Technicians (4 per shift)	$ 65,000	$ 780,000
6 Maintenance at refinery (2 per shift)	$ 25,000	$ 150,000
Harvest Crew		
4 Machine Operators (4 per shift)	$ 80,000	$ 320,000
4 Harvest Crew labor (4 per shift)	$ 30,000	$ 120,000
Total Annual Labor Costs		$1,710,000
Overall Average Total Compensation Package		$ 58,965

Projected income and costs associated with a 5 million gallon per year commercial plant for conversion of mesquite wood to ethanol are shown in Table 2. Values are based on a selling price of $2.00 per gallon of ethanol and a 5 million gallon annual yield. Costs are shown relative to the per gallon price as well as in actual dollars. The refinery is projected to cost $12 million to build. Interest on the refinery loan and depreciation costs are based on an initial cost of $12 million to build the refinery and a $0.5 million down payment. Total cost of purchasing 4 harvesting machines (2 cutters and 2 harvesters) plus transport trucks would be $2 million. Feedstock harvest and transport cost is set at $500 per acre, but our own test trials thus far suggest this value will be much lower. If the refinery is located within 10 miles of the source, we believe this is a reliable feedstock delivery estimate. Labor costs of $1.7 million from Table 1 are included. Expenses related to the actual operation of the gasification process, such as reagents, power, and maintenance, are provided by Pearson. These costs come to a little over $3 million annually, but we have no way of independently verifying these estimates.

The annual gross is $10 million. Expenses total $7.9 million. Thus, annual net income is projected at a little over $2 million for a refinery of this capacity. However, we must caution that this is a very preliminary estimate based on many assumptions that have not yet been experimentally verified.

Table 2. Production and costs associated with a 5 million gallon-per-year mesquite wood-to-ethanol commercial plant. Data are based on a combination of field trials at Vernon and estimates of factory costs provided by the Pearson Plant in Aberdeen, Mississippi.

ITEM	VALUE
Annual Gross (@ $2.00 per gallon)	$10 million
Annual Cost Details – Estimated from TAES Research	
Interest on $2 million for harvest & transport equipment (8%; $0.03/gallon)	$ 160,000
Payment to landowner for wood ($10 per acre; $0.01/gallon)	$ 35,000
Harvest and feedstock delivery ($500/acre; $0.35/gallon)	$1,750,000
Labor ($0.34/gallon)	$1,710,000
Subtotal	$3,655,000
Annual Cost Details – Estimated by Pearson BioEnergy	
Interest on $12 M to build refinery (8%; 0.19/gallon)	$ 960,000
Electric power, maintenance& repairs ($0.17/gallon)	$ 850,000
Fuel, chemicals, catalysts ($0.20/gallon)	$1,005,000
Finished product transport ($0.05/gallon)	$ 250,000
Insurance, taxes, legal, royalties ($0.09/gallon)	$ 470,000
Depreciation ($0.15/gallon)	$ 750,000
Subtotal	$4,285,000
Annual Costs Total ($1.59/gallon)	$7,940,000
Annual Net	$2,060,000

Integrating Objectives 1, 2 and 3 - One Possible Harvest Scenario

Because large diameter stems (> 3 cm or 1.25 inch diameter) do not occur in a substantial amount until about 10 years of regrowth, we believe a reasonable goal for repeated harvesting of mesquite is 10 years. It would probably not be cost-effective to harvest younger mesquite regrowth, at least in north Texas. Regrowth rates are no doubt faster in south Texas and re-harvest may be possible within shorter time intervals. Full economic projections related to these kinds of scenarios will require more research to better determine the cut off point, in terms of regrowth age, when it is economical to re-harvest mesquite. This obviously depends on stand density as well. The current study at least provides some initial figures in this regard. Based on our harvest data, the estimated wood yield of a typical multi-stemmed mesquite stand of 250 trees per acre (at 100 lbs per tree and 80 % harvest efficiency) is 10 tons per acre.

Figure 18 shows one possible landscape harvest scenario. This scenario is designed to yield a sustainable feedstock supply for the refinery *and* provide the best opportunity to enhance ecosystem diversity, herbaceous forage production for livestock and habitat for wildlife. Thus, we refer to this as an “ecologically sustainable” harvest scenario that considers more than just feedstock supply.

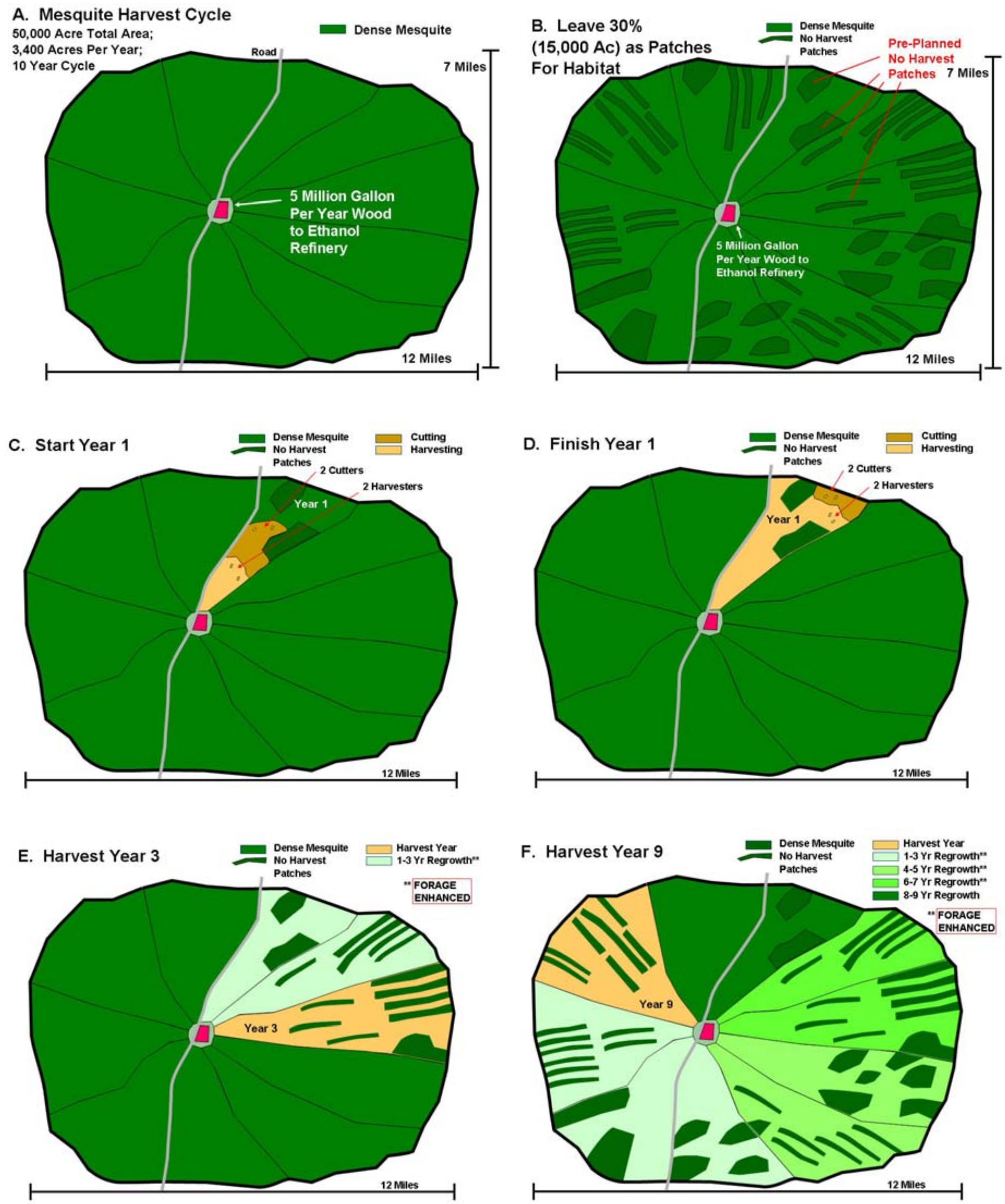

Figure 18. Harvest scenario on 50,000 acres to support a 5 million gallon per year ethanol plant (A), showing (B) pre-cut planning for wildlife habitat leaving unharvested patches, (C) initiating Year 1 harvest with cutters (brown area) followed by harvesters (tan area), (D) Year 1 completed harvest, (E) Year 3 harvest showing unharvested patches, and (F) Year 9 harvest showing different stages of mesquite regrowth and enhanced forage growth in post-harvest years 1-7.

In this scenario, we assume technology is available for a small wood-to-ethanol refinery of 5 million gallons per year capacity. Based on estimates provided by the Pearson gasification technology, we project that such a refinery would operate 330 days per year and use 100 tons mesquite feedstock per day. About 30 % of the feedstock would be recycled as short-carbon "syngas" (propane, methane, etc.), to help fuel the operation of the refinery. The other 70 % is used for finished product. This would require about 35,000 tons of mesquite per year (100 tons/day x 330 operational days). If we consider a 10 ton per acre yield level, about 3,500 acres of dense mesquite would be needed per year for such an ethanol refinery. To sustain the plant *indefinitely*, assuming regrowth rates allow re-harvest every 10 years, an area of 35,000 acres of dense mesquite would be required.

If we assume that some amount of mesquite would be left as mesquite thickets to enhance for wildlife habitat (i.e., a "brush sculpting" plan), then a more realistic scenario would require about 50,000 acres of mesquite, with 15,000 left as thickets in rows and patches (Figure 18B). Even if some of the mesquite were left for wildlife habitat, transport costs from source to refinery would be less than 10 miles if the ethanol refinery was located near the middle of the mesquite area.

The total 50,000 acre resource area would be partitioned into ten parts and one tenth of the total area would be harvested each year. The cutting machines would fell the mesquite and the harvesters would follow shortly after this (Figure 18C). A total of about 10 acres per day would need to be harvested to adequately supply the refinery. During the year of harvest, mesquite cover would be reduced to zero, as designated with the tan color on Figure 20, with the exception of the mesquite patches that would be left unharvested for wildlife habitat.

We would expect grass production to be enhanced for 6-7 years after harvest. Mesquite regrowth would be small for the first few years post-harvest, as designated by the light green color on Figure 18. The increased size of mesquite regrowth is depicted by darker shades of green on Figure 18E. Grass production data from other studies suggests that grass production would be enhanced for at least 6-7 years following mesquite harvest and would begin to decline from 8 to 10 years post-harvest. During the Year 9 harvest, we would probably find mesquite regrowth in the Year 1 harvest area begin to resemble the unharvested patches (Figure 18F). Because of the increased leaf area per tree, we would most certainly expect that grass production would be reduced significantly at this stage of mesquite regrowth. However, this area would soon be harvested a second time.

From the perspective of the land owner, there would be several benefits for such an "ecologically sustainable" harvest scenario. The landowner (1) could sell the wood from their property to the ethanol company (in Table 2, we suggest $10 per acre), (2) would have the ethanol company harvest the mesquite at no cost to the landowner, (3) would have about 6-7 years of enhanced grass growth for livestock, and (4) would enjoy increased income from wildlife hunting leases because of enhanced wildlife habitat. The landowner would have to tolerate 2-3 years of reduced grass growth for each block that was harvested. However, there would always be some part of the total area that would have enhanced grass growth at any single point in time, as Year 9 illustrates (Figure 18F).

Regional and Statewide Economic Projections

We estimate there are 4 million acres of moderate to heavy density mesquite that can be harvested in the Rolling Plains of north Texas (roughly the triangle between Lubbock, Wichita Falls and Abilene). Extrapolating to the state level, there are about 30 million acres of dense mesquite in the state. If half of this was used, the other half left to support wildlife habitat and recreational hunting, it could support about 400 ethanol plants. At 5 million gallons per refinery this could yield 2 billion gallons of ethanol which is 4% of the estimated 47 billion gallons of oil that the state of Texas consumes every year. Each refinery would employ about 27 per refinery, at an average of $50,000 per employee.

This demonstrates that, while ethanol from brush would not replace oil, it could relieve a significant percentage of the current oil usage. Moreover, this projection is based on only harvesting 50 % of the dense wood, so there is room for expansion. Of course, this is a long term plan and it make take decades to build that many small refineries, but this represents a long-term planning horizon. However, *the most important concept* in all of this is that this is truly a *renewable fuel source* that will require no cultivation, planting or fertilizing costs to maintain the resource. In addition, ranchers will enjoy the benefit of less brush to grow more herbaceous forage for livestock. Forage production could increase by 50 to 100% on mesquite harvested areas, thus generating the potential of doubling income from livestock.

Locations such as Truscott, Aspermont, Vernon, Crowell or larger cities such as Abilene or San Angelo would be ideally suited for location of such a refinery. Alternatively, if a refinery could dual-process mesquite wood and cotton gin trash into ethanol, then areas that have both cotton and nearby mesquite would be suitable. Small rural towns such as Snyder, Dickens, Paducah, Quanah, Munday or Vernon would be suited for such dual use.

Objective 4

The primary focus of this objective was to present results of this project to the public and increase the visibility of biofuel as an alternative fuel source. In addition to giving several presentations on the subject in the last 2.5 years, the Texas Agricultural Experiment Station successfully conducted a field day on October 5, 2006 in Vernon to demonstrate the field capability of the harvester and show some of the preliminary data. This field day combined several topics related range and wildlife ecology. The mesquite biofuel project was a major component of the all-day event.

An indoor session was held in the morning from 8:30 am to noon. During this session, Dr. Ansley gave a 30 minute presentation on the project. After lunch, buses took participants to the field site on the Smith-Walker Research Ranch near Vernon for a demonstration of the harvester (Figure 19). Funding from the SECO grant paid for the bus trip to the field site.

At the field site, two machines were demonstrated. The first machine, a Barko 775C, owned by Mr. Richard Frailey, Brush Unlimited, felled the mesquite trees and left wood mulch on the soil surface (see Figures 1 and 2). The second machine, the recently completed harvester from

Objective 1, was pulled over another area of previously downed wood (Figure 20). The wood mulch was collected in a basket and then hydraulically dumped into a truck (Figure 21).

Over 150 attended the field day which was somewhat lower than we expected. We charged $10 per person to cover lunch costs and this may have reduced attendance of those who ordinarily would attend of the event was free. U.S. Representative Mac Thornberry and his aids attended specifically to learn about the mesquite biofuels project. State Representative Mike Schultz from southwestern Oklahoma and Texas State Representative Rick Hardcastle also attended. It was considered a successful field day and has generated a lot of visibility.

Figure 19. Dr. Jim Ansley at the field day site near a pile of recently harvested mesquite wood.

Figure 20. Inspecting the operation of the mesquite harvester pulled by the HydroAxe.

Figure 21. Mesquite wood dumped out of the harvester basket using the hydraulic assembly.

Communications Regarding the Project

Included below are lists of (1) the presentations Dr. Ansley has given related to this project, (2) some of the web site “hits” related to this project by entering in Google, three words: mesquite ethanol ansley, and (3) some hard copy publications of news articles about this project through December, 2006. From August 2004 to December 2006, Dr. Ansley has given 13 presentations on the topic. Eleven of these were invited presentations.

Invited Presentations

Ansley, R.J. 2004. Potential of mesquite as biomass for ethanol. Presentation at Waste-to Energy Workshop, State Energy Conservation Office (SECO), 17Aug04, Lubbock, TX.

Ansley, R.J. 2005. Mesquite for bioenergy uses. Presentation at Vernon Rotary Club, 15Feb05, Vernon, TX.

Ansley, R.J. 2005. Mesquite for bioenergy. Presentation at Rural Alliance for Renewable Energy Symposium, 24Oct05, San Angelo, TX.

Ansley, R.J. 2006. Potential of rangeland woody plants as a bio-energy source. Presentation at Bio-Energy Workshop, 05Apr06, Texas Agric. Exp. Station, Amarillo, TX.

Ansley, R.J. 2006. The potential of rangeland woody plants as biomass for ethanol. Presentation at Texas Farm Bureau Annual Convention, 27Jun06, Marble Falls, TX.

Ansley, R.J. 2006. The potential of rangeland woody plants as biomass for ethanol. Presentation to Lewis Britt and Kate Williamson, assistants to Rep. Mac Thornberry, U.S. House of Representatives, 28Aug06, Vernon, TX.

Ansley, R.J. 2006. Potential of rangeland woody plants as a biofuel. Texas A&M University Presentation at Bio-Energy Workshop, 01Sep06, College Station, TX.

Ansley, R.J. 2006. Biomass technologies. Presentation at BioEnergy-Texas Conference, 25Oct06, Lubbock, TX.

Ansley, R.J. 2006. Mesquite ecosystem responses to disturbances and implications for alternative landscape management strategies. Texas A&M Univ. Ecosystem Science and Mgt. Seminar Series, 07Nov06, College Station, TX.

Ansley, R.J. 2006. Feasibility of mesquite to ethanol bioenergy. Presentation at 20th Annual Beef Cattle Improvement Conference, 16Nov06, Cameron University, Lawton, OK.

Ansley, R.J. 2006. Demonstration of mesquite harvester. Presentation to San Angelo mayor and chamber of commerce members, 12Dec06, Vernon, TX.

Volunteer Presentations

Ansley, R.J. 2004. Rangeland woody plants as renewable biomass for energy needs. Abstr. In: Proceedings Sun Grant Initiative Conf., June 2004, Oklahoma City, OK.

Ansley, R.J. 2006. Feasibility of mesquite to ethanol. Texas Agricultural Experiment Station Field Day - Indoor Presentation, 05Oct06, Vernon, TX.

Web Site Hits (By entering on Google: mesquite ethanol ansley)

As of December 15, 2006 there were over 1200 web site hits related to the mesquite-to-ethanol topic. Sources such as MSNBC (October 20), the Dallas Morning News, the Ft. Worth Star Telegram, Netscape, Ecofriend, Biology Daily, Southwest Farm Press, Crop News Weekly, the Houston Chronicle, Terra Daily, and Green Car Congress have covered the project. The field day event also made the front page as the feature article in the Wichita Falls Times Record News on October 6th. Dr. Ansley has given several phone interviews, including a call from Radio Station KMOX out of St. Louis.

The news releases occurred in two waves. The first from April to July 2006 were mainly the result of an article Kay Ledbetter wrote about the project. The second wave from October to December, was mainly the result of the press received from the field day. There seems to be an even mix of traditional farm/ranch news outlets and more ecologically oriented outlets, but clearly this has struck a chord with the environmental community in addition to ranchers wanting to do something with their mesquite. The Biopact web site listed below (October 12th) provided one of the better articles that summarized the first and second wave of news releases. A very nice article was written by J.T. Smith in the December issue of the Farmer-Stockman. Some of these web site hits and printed articles are listed below in chronological order:

http://agnews.tamu.edu. Economic boost may be fueled by agriculture. Author: Kay Ledbetter. April 7, 2006.

http://csrees.usda.gov. Economic boost may be fueled by agriculture. USDA Newsroom. Author: Kay Ledbetter. April 7, 2006.

www.thebatt.com. Fuel for the fire - should the United States pursue ethanol as a new fuel source? Author: D. Abasolo and M. Warren., June 14, 2006.

www.fsunews.com. Fuel for the fire - should the United States pursue ethanol as a new fuel source? Author: D. Abasolo and M. Warren., June 19, 2006.

http://agnews.tamu.edu. From campfire to gas tank, mesquite energy may be harnessed for ethanol. Author: Kay Ledbetter. June 21, 2006.

http://biosphere.biologydaily.com. From campfire to gas tank, mesquite energy may be harnessed for ethanol. Author: Kay Ledbetter. June 21, 2006.

www.eurekalert.org. From campfire to gas tank, mesquite energy may be harvested for ethanol. Author: Kay Ledbetter. June 22, 2006.

http://southwestfarmpress.com. From campfire to gas tank, mesquite energy may be harnessed for ethanol. Author: Kay Ledbetter. June 22, 2006.

www.innovations-report.com. From campfire to gas tank, mesquite energy may be harnessed for ethanol. Author: Kay Ledbetter. June 22, 2006.

www.enews.prismb2b.com. From campfire to gas tank, mesquite to ethanol? Crop News Weekly. Author: Kay Ledbetter. June 22, 2006.

www.sciencedaily.com. From campfire to gas tank, mesquite energy may be harnessed for ethanol. Author: Kay Ledbetter. June 23, 2006.

www.brightsurf.com. From campfire to gas tank, mesquite energy may be harnessed for ethanol. Author: Kay Ledbetter. June 23, 2006.

www.tfb.org. Mesquite: from scrub brush to gas tank? The Cornerpost, June 23, 2006.

www.greencarcongress.com. Researcher explores mesquite-to-ethanol. June 23, 2006.

www.ecofriend.org. Spiny mesquite trees can produce ethanol! June 26, 2006.

http://blogs.chron.com/sciguy. Mesquite - the new black gold? Author: Eric Burger, The Houston Chronicle. June 26, 2006.

www.terradaily.com. Mesquite energy may be harvested for ethanol. June 27, 2006.

http://starphoenixbase.com. Tasty, mesquite-flavored ethanol on the way. Author: Val

Germann. June 28, 2006.

www.eesi.org. Texas to use mesquite for biofuels production. BCO Newsletter. July 2006, Issue 33, page 14.

www.biodieselinvesting.com. Texas may harness mesquite as ethanol source. July 18, 2006.

www.hesperianbeacon.com. Ethanol plant bringing jobs. Author: Alice Gilroy. Floyd Co. Hesperian- Beacon, August 3, 2006.

www.sciencedaily.com. Harvesting machine driving mesquite-to-ethanol potential. October 6, 2006.

www.grinzo.com. Cash crop: demo shows money may grow on trees. October 9, 2006.

www.dallasnews.co. Research focuses on turning mesquites into fuel. Author: Lara Richards, The Dallas Morning News, October 10, 2006.

www.dfw.com/mld/startelegram. Research focuses on turning mesquites into fuel. Fort Worth Star Telegram, October 10, 2006.

http://agnews.tamu.edu. Harvesting machine driving mesquite-to-ethanol potential. Author: Kay Ledbetter. October 11, 2006.

www.eurekalert.org. Harvesting machine driving mesquite-to-ethanol potential. Author: Kay Ledbetter. October 11, 2006.

www.dailytexanonline.com. A&M researches fuel made from mesquite. Author: Lara Richards. October 11, 2006.

www.theeagle.com. A&M researchers focus on using trees to make ethanol. October 11, 2006.

www.dfw.com. A tree in your tank? Ft. Worth Star-Telegram. October 11, 2006.

www.whatsnextnetwork.com. New machine makes harvesting mesquite for ethanol easier. What's Next In Science and technology, October 11, 2006.

www.popular-news.com. Harvesting machine driving mesquite-to-ethanol potential. October 11, 2006.

www.phpbbserver.com/lonestarfireman. A&M researchers focus on using trees to make ethanol. The Lonestar Fireman. October 12, 2006.

http://biopact.com. Turning pest into profit: drought-tolerant mesquite shrub as a biofuel feedstock. October 12, 2006 (one of the better articles that summarizes the first and second wave of news releases).

www.biofuelreview.com. Harvesting machine opens up options for mesquite-to-ethanol potential. Author: Kay Ledbetter. October 12, 2006.

www.321energy.com. Harvesting machine driving mesquite-to-ethanol production. October 12, 2006.

www.iran-daily.com Fuel from mesquites. October 17, 2006.

www.msnbc.com. From foe to fuel? Texas eyes mesquite. Author: Lara Richards. October 20, 2006.

www.reporter-news.com. Fill it up - with mesquite? - thorny pest could end up fueling your car. Author: Trish Choate. October 24, 2006.

www.ecofriend.org. New machine to make ethanol-producing mesquite harvesting easier. Author: Irani, October 26, 2006.

www.agr.state.tx.us. Wood-to-ethanol production. Letecia Torres interview of Dr. Ansley, Texas Dept. of Agric. October, 2006.

http://h2opower.blogspot.com Fuel from mesquites. November 1, 2006.

www.alternative-energy-news.info. Mesquite to ethanol machine. November 2, 2006.

www.johahthomas.cronkite.newsvine.com. Mesquite to ethanol machine. November 2, 2006.

www.okinsider.com. Cameron's beef cattle improvement conference will feature renowned speakers. Oklahoma Insider, November 11, 2006.

www.gosanangelo.com. Mesquite ethanol plan win-win. Author: Jerry Lackey, San Angelo Standard-Times. November 12, 2006.

www.netscape.com/tag/ethanol. Mesquite to ethanol machine. December 20, 2006.

Newspaper and Trade Journal Articles

The Fenceline. Economic boost may be fueled by agriculture. Texas Cooperative Extension, April/May/June 2006, page 4.

Jacksboro Gazette. 2006. Mesquite energy may be harnessed for ethanol. June 27, 2006, page 9.

Ledbetter, K. 2006. Farming mesquite for ethanol. The Farmer Stockman, Sept. 2006, page 28.

Raff, J. 2006. Make field day of learning new ranching techniques. Wichita Falls Times Record News, Page 3B, Sept. 9, 2006.

Editorial Staff. 2006. Overlooked - area professor has been working for years to develop alternative fuel. Wichita Falls Times Record News, Sept. 21, 2006.

Richards, L.K. and T. Choate. 2006. Cash crop - demo shows money may grow on trees.

Wichita Falls Times Record News, Front Page article, October 6, 2006.

Choate, T. 2006. Biofuel may prove blessing to north Texas. Wichita Falls Times Record News, Front Page article, October 6, 2006.

Vernon Daily Record. Mesquite harvester photograph. Vernon Daily Record, October 6, 2006.

The Valley Tribune, Quitaque, Texas. Harvesting machine driving mesquite-to-ethanol potential. October 19, 2006.

The Ward County Range Steward. Harvesting machine driving mesquite-to-ethanol potential. Texas Cooperative Extension, Sept.-Oct., 2006, page 3.

Ledbetter, K. 2006. Trees and brush have ethanol potential. Brangus Journal. November 2006 Issue, page 32.

Sutton County Agriculture/Horticulture Newsletter. Harvesting machine driving mesquite-to-ethanol potential. Texas Cooperative Extension, November 2006, pages 1-2.

Smith, J.T. 2006. Mesquite to ethanol: works grinds forward. The Farmer Stockman, December 2006, pages 10-11.

Staff, Texas Coop Power. 2006. Is mesquite the next biofuel? Texas Coop Power. December 2006, page 4.

Cost Share Breakdown (Appendix A)

Appendix A summarizes the total costs related to the project, organized by objective and by collaborator. Total cost of the 3-year project was over $305,000. The SECO grant provided about 18 % of this total. This does not include about $20,000 that was taken as indirect costs by TAES administration at College Station. The Texas Agricultural Experiment Station contributed about 39 % of the total. Industry collaborators collectively contributed about 43 % of the total.

The greatest expense, of course, was the design and construction of the harvester for Objective 1 (over $118,000). This would not have been possible without a significant infusion of funds from TAES and volunteer work by the industry collaborators. As stated earlier, the actual hard dollars that were spent on the construction of the harvester included $31,103 by TAES and $12,312 by SECO. Industry collaborators volunteered nearly $50,000 worth of time and labor that was not charged.

APPENDIX A

Expense items and dollar contributions of each collaborator related to the Mesquite Biofuel Project, CM-406, organized according to project objective. Contributions of the SECO grant are listed under the SECO column. TAES=Texas Agricultural Experiment Station. WW Welding, Frailey, Sneed and Pearson are the industry collaborators.

Objective and Expense Item	TAES	SECO	WW Welding	Frailey	Sneed	Pearson	Cross Sum
Obj 1 - Harvester Construction							
Harvester Design			15000	15000	500		30500
Harvester Construction/Repair	31103	12312	10665	5000			59080
Justice Inc. Labor & Expenses		10532					10532
Sneed Travel Expenses		200			200		400
Sneed Time					1000		1000
Ansley Travel Expenses	300						300
Ansley Salary (10 wks)	15000						15000
Ansley Supp. Staff Salary (3 wks)	1800						1800
SUBTOTAL	48203	23044	25665	20000	1700	0	118612
Obj 2a - Harvester Trials							
Field Trial Expenses	500	3000	2100	10000			15600
Ansley Temp Wage Labor	1000	1000					2000
Ansley Salary (5 wks)	7500						7500
Ansley Supp. Staff Salary (8 wks)	4800						4800
SUBTOTAL	13800	4000	2100	10000	0	0	29900
Obj 2b - Regrowth mass							
Expenses	500	2000					2500
Ansley Temp Wage Labor	6000	8500					14500
Ansley Salary (8 wks)	12000						12000
Ansley Supp. Staff Salary (8 wks)	4800						4800
SUBTOTAL	23300	10500	0	0	0	0	33800
Obj 3 - Ethanol Conversion							
Sneed Travel Expenses		892					892
Sneed Expenses		1886					1886
Sneed Time					8000		8000
Pearson BioEnergy Expenses		10000				48166	58166
Ansley Travel Expenses	200						200
Ansley Salary (4 wks)	6000						6000
SUBTOTAL	6200	12778	0	0	8000	48166	75144

Appendix A (continued).

Objective and Expense Item	TAES	SECO	WW Welding	Frailey	Sneed	Pearson	Cross Sum
Obj 4a - Increasing Awareness							
Sneed Travel Expenses		700			2000		2700
Sneed Time					8000		8000
Frailey Expenses				2000			2000
Ansley Travel Expenses	2000	67					2067
Ansley Salary (8 wks)	12000						12000
SUBTOTAL	14000	767	0	2000	10000	0	26767
Obj 4b - Field day							
General Expenses	1000	500					1500
Indoor and Field Site Preparation	1000						1000
Bus Rental		1800					1800
Frailey Expenses	40			2000			2040
WW Welding Expenses	20		1000				1020
Ansley Salary (4 wks)	6000						6000
Ansley Supp. Staff Salary (12 wks)	5200	2000					7200
Other Supp. Staff Salary (2 wks)	1200						1200
SUBTOTAL	14460	4300	1000	2000	0	0	21760
GRAND TOTAL	119963	55389	28765	34000	19700	48166	305983
PERCENT OF GRAND TOTAL	39.2	18.1	9.4	11.1	6.4	15.7	100